# Seismometer to Investigate Ice and Ocean Structure (SIIOS)

Completed Technology Project (2017 - 2019)

## Project Introduction

The icy moons of Europa and Enceladus are thought to have global subsurface oceans in contact with mineral-rich interiors, likely providing the ingredients needed for life as we know it. The possibility of life forming in the ocean or in melt pockets, relies on the presence of a source of energy and chemistry for biological molecule formation. A thick, stagnant ice crust would likely prevent transfer of oxidants from the surface to the water, halting the development of life. The ice thickness and structure is therefore one of the most important and controversial topics in astrobiology. The best way to access the icy moon interior structure is with a lander-based seismometer. Our team has identified a commercial-off-the-shelf (COTS) device as a flight-candidate for operation in the extreme environment of the icy moons. The COTS device is capable of detecting the ice-water boundary and pockets of liquid within the ice. Its low mass and low power enables deployment of multiple seismometers in a short-baseline array on a lander. The performance, mass, volume, and other characteristics of this device meet or exceed flight requirements identified in lander studies making a field test of these seismometers highly representative of a flight unit developed for an Ocean Worlds mission. Objectives. We propose to demonstrate the field sensitivity of a short-baseline (1-4 m) seismic array to the detection of seismicity from active and passive sources, the depth of ice-water boundaries, and to the ice properties within terrestrial analog environments for an Ocean World. Our work will quantify and advance key mission requirements for robotic science operations, including the flight data rates and data volumes, algorithms for extraction of signals, and the optimal array geometries needed for seismic science on an Ocean World. The project will demonstrate the fidelity of sensitive miniature seismic sensor technology to Ocean World science, and develop a recommendations for best practices of small aperture seismic array science in planetary exploration. Methodology. Our seismic field validation requires access to the icy analog environments of a glacier in Alaska and the Ross Ice Shelf in Antarctica. The Alaskan glacier provides short-baseline array, passively-induced seismic time series for the evaluation of data rates and processing requirements. The Ross Ice Shelf 1) is rich in natural seismic activity, 2) has relatively thick ice overlying liquid water that is needed to validate our seismic methods for determining ice thickness, and 3) provides ready access to ices of varying porosity and icy surface properties needed to simulate near surface conditions on Ocean Worlds. Relevance. Our project will demonstrate the operations, science, and technology needed for the execution of a small aperture seismic array deployed on an Ocean World. Our tests will be performed on thick ice over liquid water in analog environments to demonstrate how small aperture seismic array data can address the key science questions posed by an Ocean Worlds lander mission. The proposed research will result in new science as well as operational and technological capabilities that will enable the next generation of planetary exploration. The proposed activities will include training of students, public outreach, and collaboration of academic institutions with an industry partner.


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## Organizational Responsibility

**Responsible Mission Directorate:**

Science Mission Directorate (SMD)

**Responsible Program:**

Planetary Science and Technology Through Analog Research

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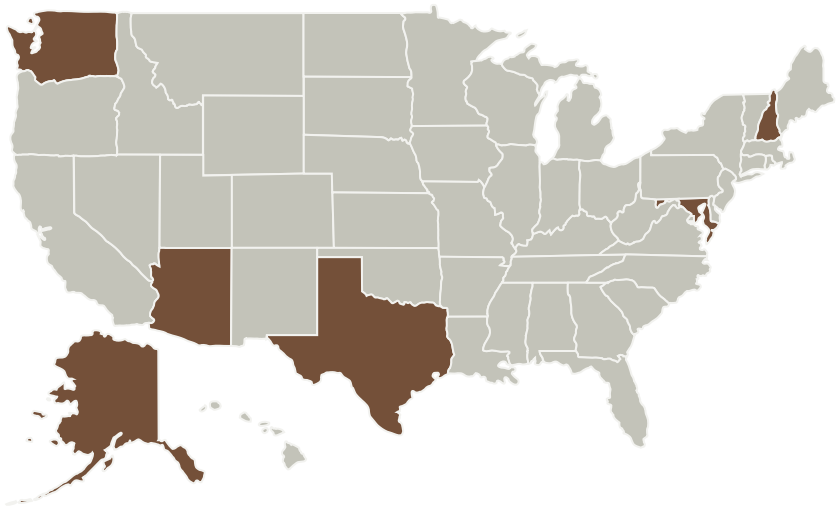
## Primary U.S. Work Locations and Key Partners



| Organizations Performing Work | Role | Type | Location |
|---|---|---|---|
| University of Arizona | Supporting Organization | Academia<br>Alaska Native and Native Hawaiian Serving Institutions (ANNH), Hispanic Serving Institutions (HSI) | Tucson, Arizona |

| Primary U.S. Work Locations | |
|---|---|
| Alaska | Arizona |
| Maryland | New Hampshire |
| Texas | Washington |

## Project Management

**Program Director:**
Carolyn R Mercer

**Program Manager:**
Sarah K Noble

**Principal Investigator:**
Samuel H Bailey

**Co-Investigators:**
Peter H Dahl
Brad Avenson
Mary Gerrow
Nicholas Schmerr
Donald G Albert
Veronica J Bray
Erin C Pettit
Daniella N Della-giustina
Shane Byrne

## Technology Areas

**Primary:**

- TX01 Propulsion Systems
  - TX01.3 Aero Propulsion
    - TX01.3.11 Engine Icing

## Target Destination

Others Inside the Solar System